Sources of North American pollution outflow : analysis with TES summer 2006 observations

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Abstract : The Tropospheric Emission Spectrometer (TES) observed a large number of ozone, CO and water vapor latitudinal cross sections over the northern midlatitudes between 130W to 15E. The general objective of this study is to use TES to better characterize the outflow from North America to North Atlantic in summer 20006 and relate it to the sources over North America and assess its impact on the air quality in Europe. We present a preliminary interpretation of the CO and Ozone measurements in term of transport of pollution from North America to Europe using simultaneous meteorological observations and the tropospheric chemistry transport model GEOS-Chem.

TES data

TES performed an extensive observation of the Northern Midlatitudes during the summer 2006. Between July04 and August 21 2006, CO and O_3 TES profiles from 144 Step and Stare and 26 Global Surveys are available for our study.
Step/Stare runs have dense nadir coverage, about 0.4 apart, and covers a 50 latitude range.

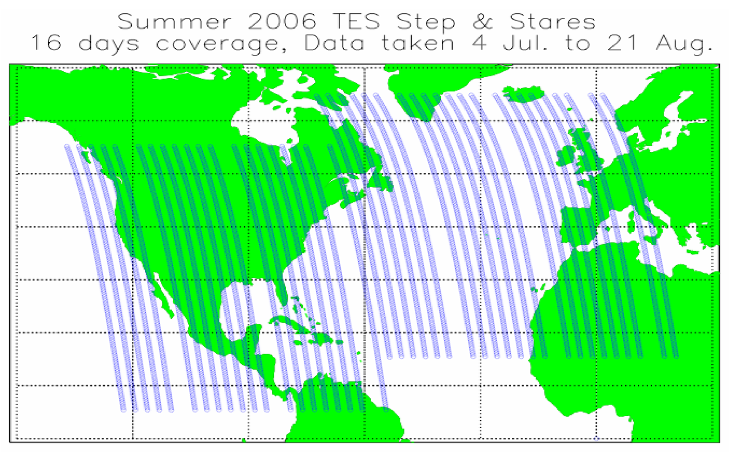


Figure 1 : Measurement locations of the TES Special Observations performed during the summer 2006 over the Northern Midlatitudes for a 16 days period. Each track was repeated 3 times over the summer.

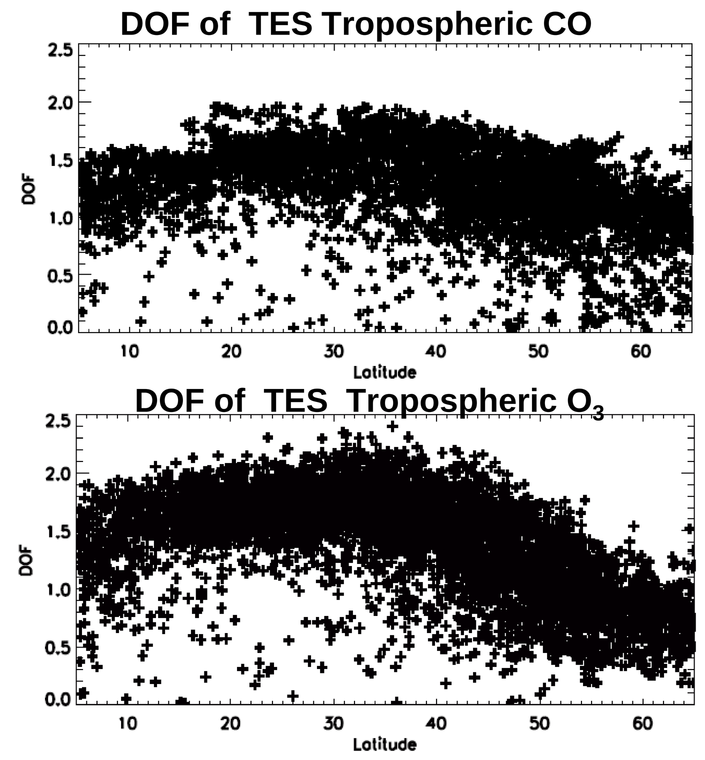


Figure 2 : Latitudinal variation of the Degree of Freedom for signal (DOF) for the tropospheric part of the TES CO and ozone retrievals for the Special Observations of July 2006.

Evaluation of TES ozone over US by comparison with ozonesondes from the IONS project

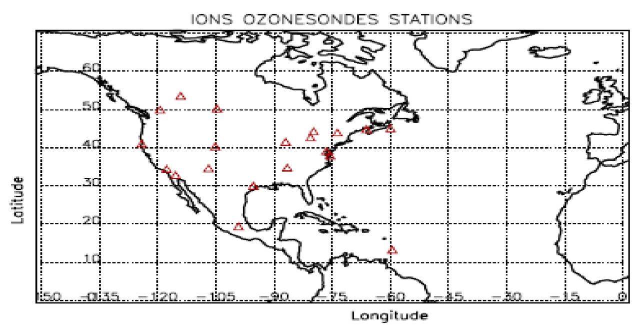
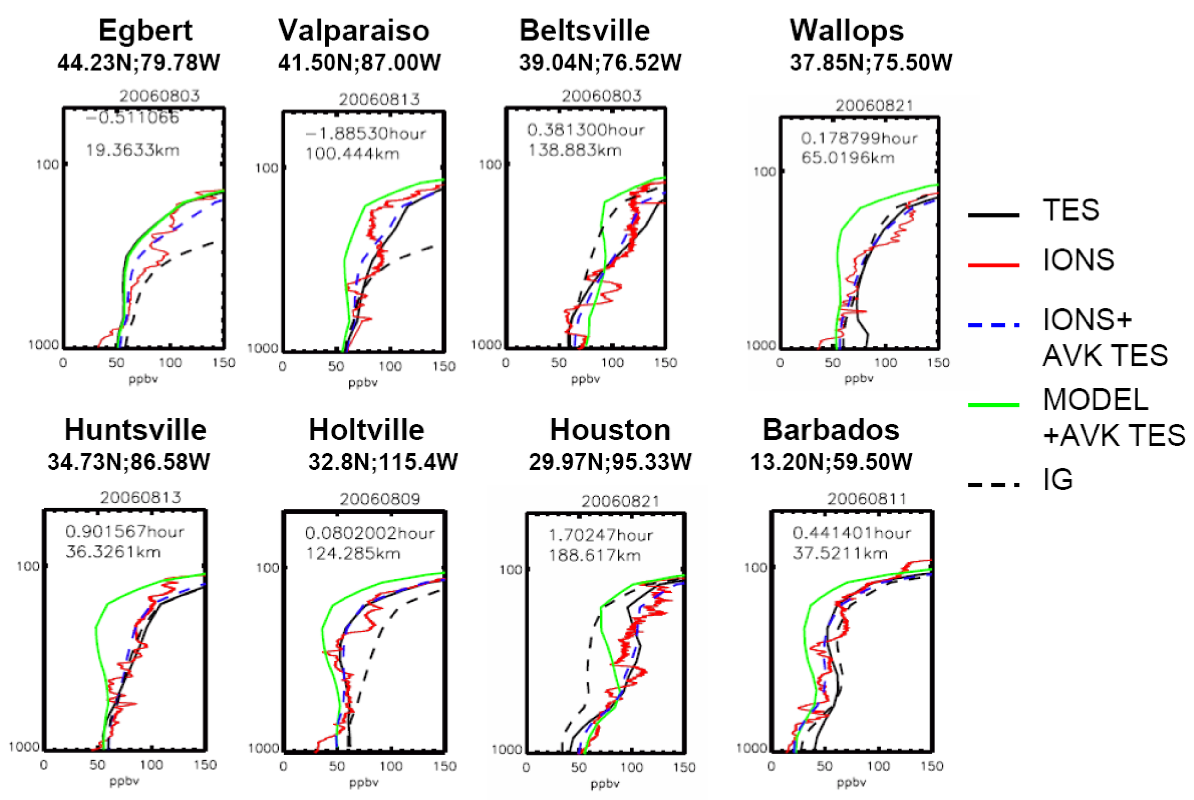


Figure 3 : Locations of the IONS ozonesonde stations.



We find that TES compares well with the ozonesondes. GEOS-Chem tends to underestimate ozone in the middle and upper troposphere (by up to 40 ppbv).
Work in progress : statistical analysis, comparison between IONS, TES and GEOS-Chem ozone in the framework of case studies (lightning related).

Export of Pollution from North America using TES, meteorological data and GEOS-CHEM

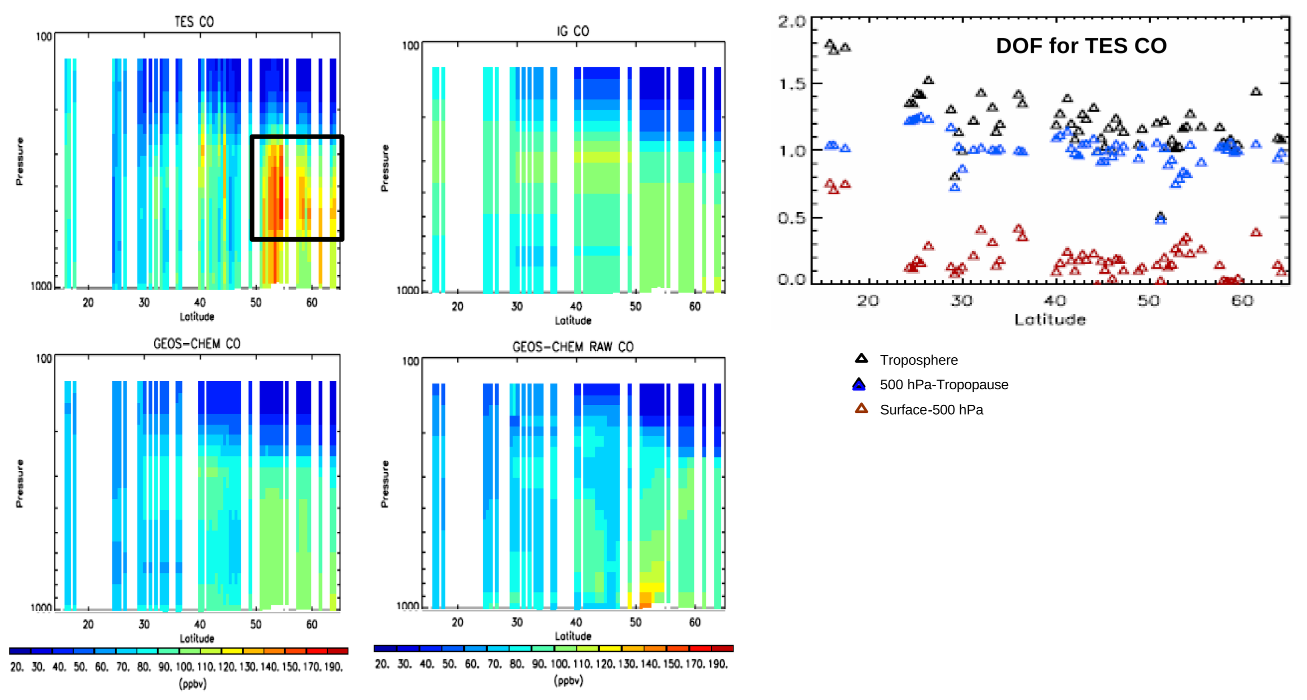


Plate 1 : CO mixing ratios retrieved by TES and simulated by GEOS-Chem over the Northern Atlantic Ocean (above) on July 8, 2006. The initial guess is also shown as well as the GEOS-Chem field without TES operator and the latitudinal variation of the DOF (troposphere, regions below and above 500 hPa).

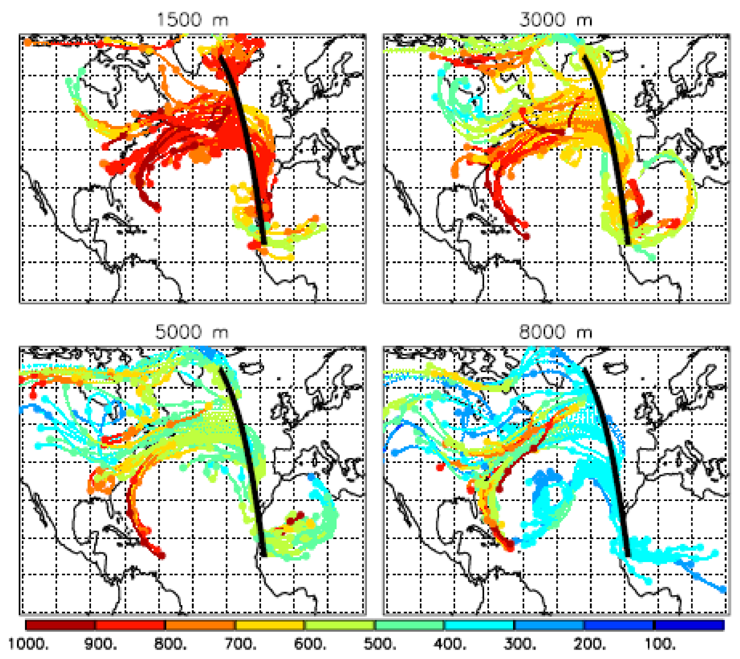
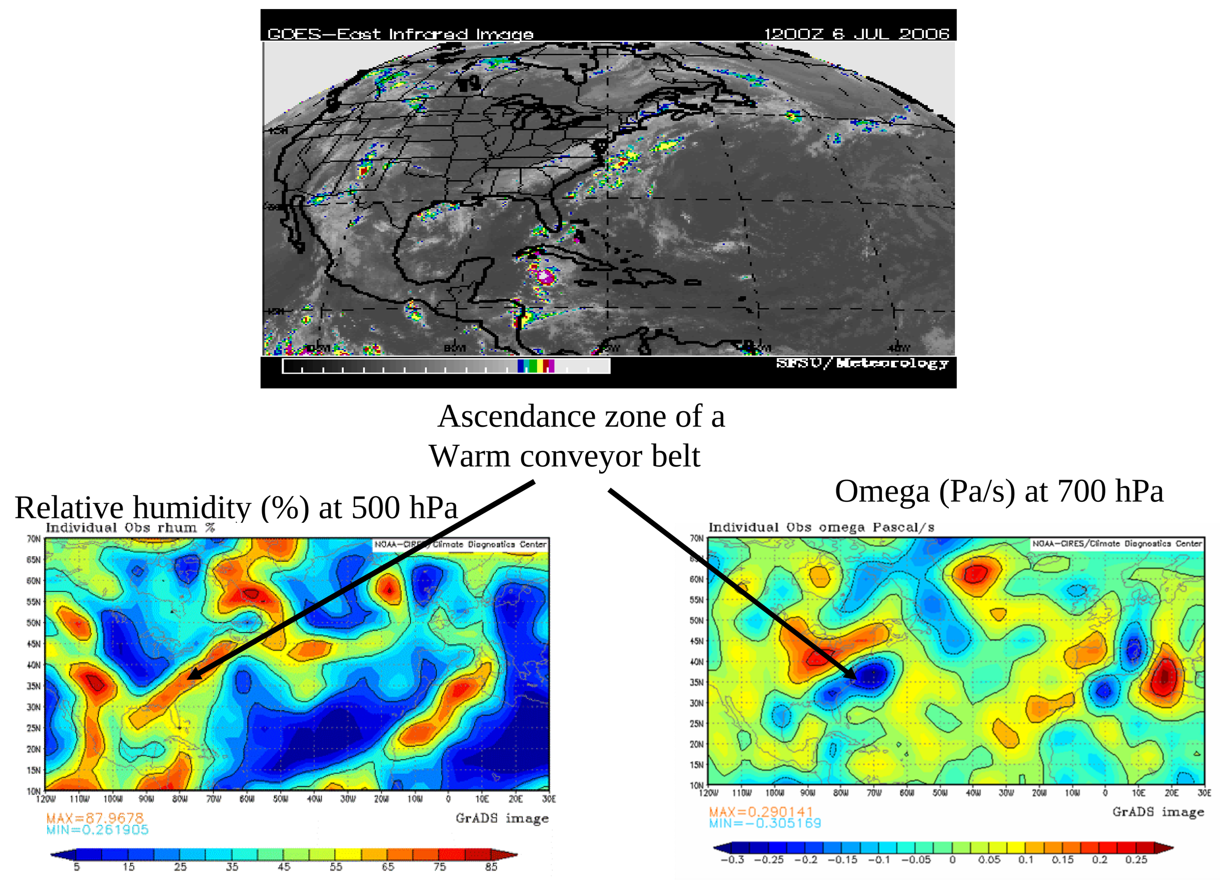


Figure 4 : Five-day backward trajectories initialized from the location and time of the TES Step/ Stare at 1500, 3000, 5000 and 8000 meters.



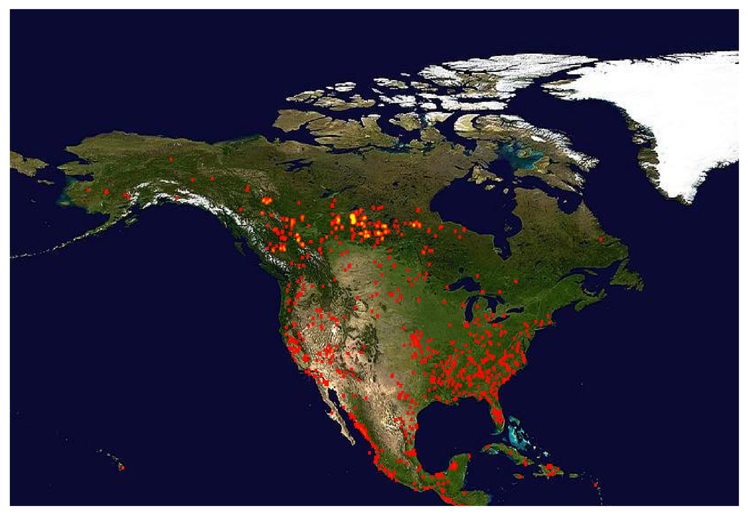


Figure 5 : MODIS fire counts for the first week of July 2006 .

Lightning influence on Ozone over North America using TES, NLDN data and GEOS-CHEM

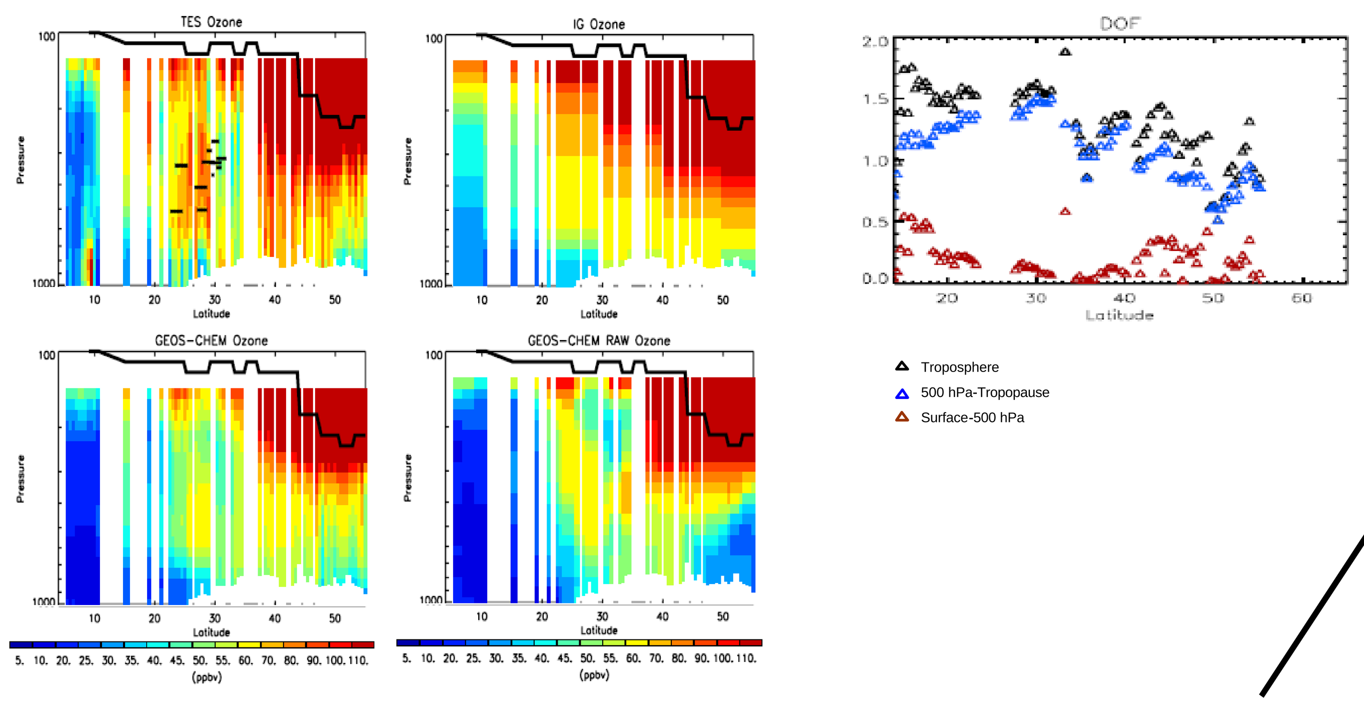


Plate 2 : Ozone mixing ratios retrieved by TES and simulated by GEOS-Chem **(Step/Stare 4497 of the figure 6)** over North America on July 12 , 2006 The initial guess is also shown as well as the GEOS-Chem field without TES operator and the latitudinal variation of the DOF (troposphere, regions below and above 500 hPa). The black symbols represent the latitude and pressure of trajectories emanating from locations of lightning observed by the NLDN and intersecting the Step and Stare.

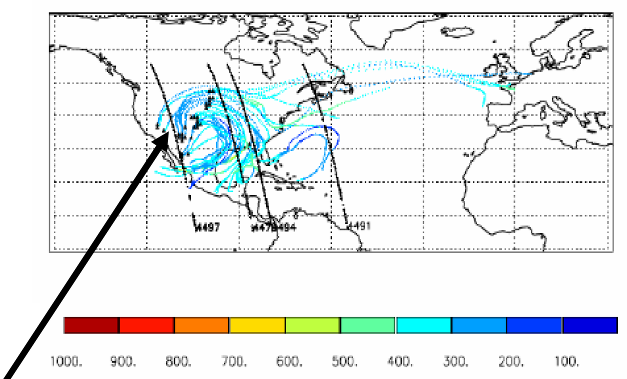


Figure 6: Five-day forward trajectories initialized at 8km from the location of the lightning flashes (triangles) observed by the NLDN on July 8, 2006. Only Flash densities larger than 0.2 Flash/km2/day are used. TES Step and Stare intersecting the trajectories are shown.

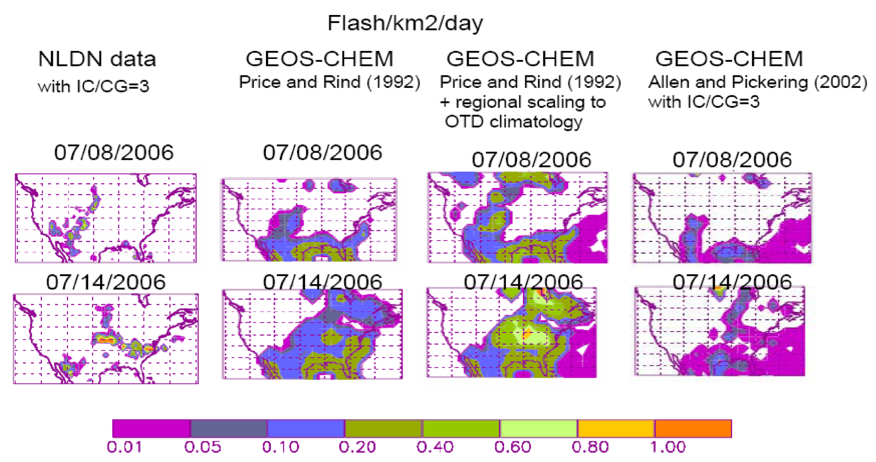
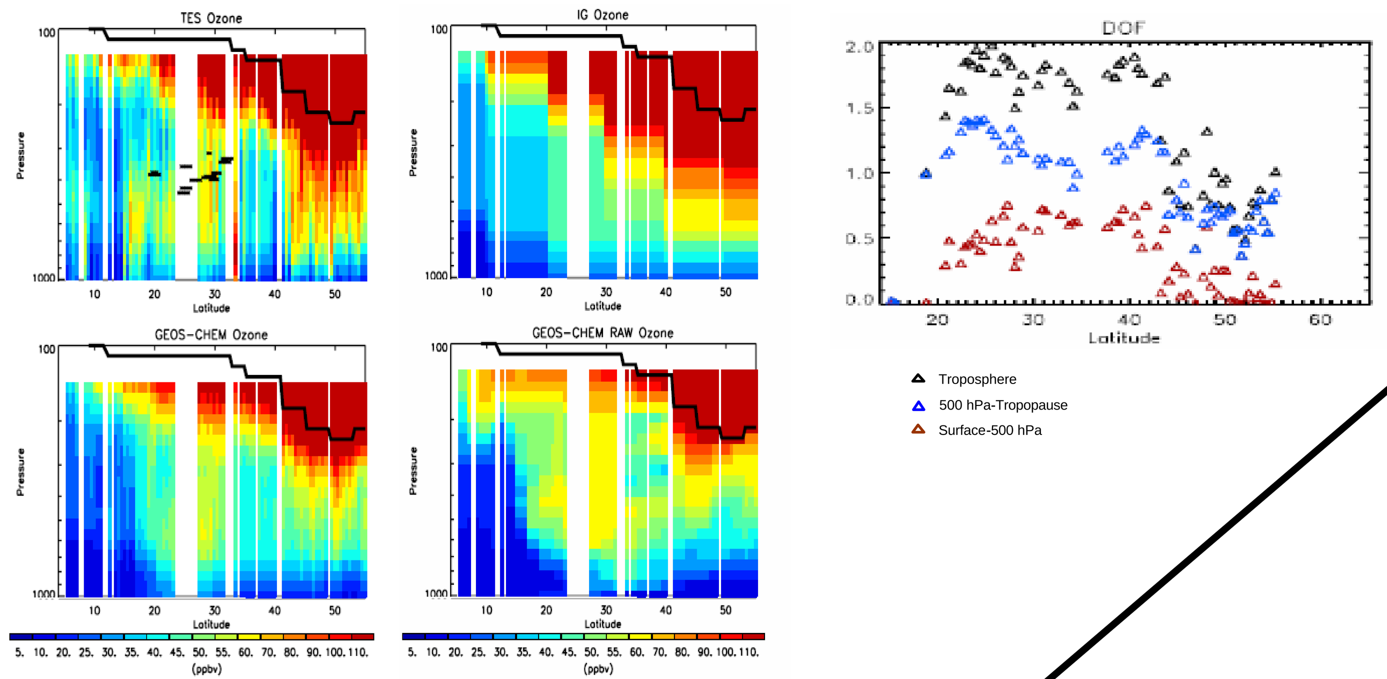


Figure 8 : Comparison between the distribution of lightning flash densities from NLDN and GEOS-Chem using different parameterizations for July 8, and 14 2006.



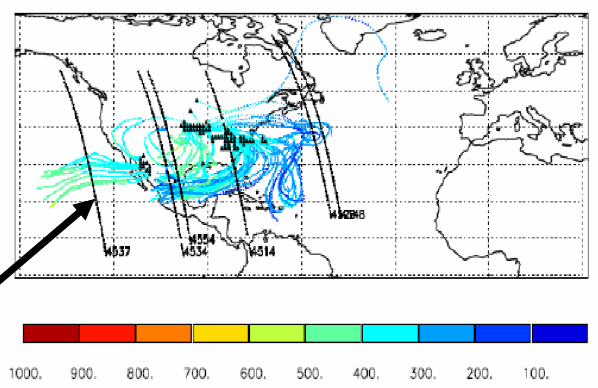


Figure 7: Five-day forward trajectories initialized at 8 km from the location of the lightning flash (triangles) observed by the NLDN on July 14, 2006. Only flash densities larger than 0.2 Flash/km2/day are used. TES Step and Stare intersecting the trajectories are shown.

Plate 3: same than in Plate 2 but for July16, 2006 (**Step and Stare 4537 of the figure 8**).

CONCLUSIONS

NORTH AMERICAN OUTFLOW :

• TES observes CO mixing ratios values typical of the polluted boundary layer over the high latitudes of Western Europe and North Atlantic Ocean in the upper and middle troposphere in July 2006. The trajectory analysis shows that these enhancements result from the long-range transport of air masses from the North American boundary layer in particular from the East Coast of United States and from Canada (Canadian Maritime Provinces and Newfoundland). These trajectories also show that the air masses have their origin over biomass burning areas in Canada (West of the Hudson bay) in July 2006.

WORK IN PROGRESS : - Validation of TES data with MOZAIC, MOPITT and GEOS-Chem.
- Assimilation of TES CO in GEOS-CHEM in order to provide insights into model deficiencies (emissions or/and transport)

IMPACT OF LIGHTNING :

• TES ozone retrievals compares well with IONS ozonesondes measurements over North America in summer 2006.

• TES ozone retrievals can be analyzed in conjunction with NLDN lightning data to give information on the impact of lightning on ozone production.

WORK IN PROGRESS - Sensitivity study with the GEOS-Chem model to understand the influence of lightning sources on the ozone variability over the US.

We thank K. Pickering for providing us the NLDN (National Lightning Detection Network) data.
NLDN and LRLDN data were collected by Vaisala-Thunderstorm and archived at the Global Hydrology Resource Center (GHRC) at NASA Marshall Space Flight Center.
We are thankful to the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model (http://www.arl.noaa.gov/ready/hysplit4.html) used in this study.